

Abstract Title Page

Title: A Randomized Controlled Trial Validating the Impact of the LASER Model of Science Education on Student Achievement and Teacher Instruction

Authors and Affiliations:

Dr. Carolyn R. Kaldon, Center for Research in Educational Policy, University of Memphis

Dr. Todd A. Zoblotsky, Center for Research in Educational Policy, University of Memphis

Background / Context

Previous research has linked inquiry-based science instruction (i.e., science instruction that engages students in doing science rather than just learning about science) with greater gains in student learning than text-book based methods (Vanosdall, Klentschy, Hedges & Weisbaum, 2007; Banilower, 2007; Ferguson 2009; Bredderman, 1983; Shymansky, Hedges, & Woodworth, 1990). The LASER model, being validated in the current study, has already been the subject of a number of case studies (RMC Research Corporation, 2010; Horizon Research, 2010; Vanosdall et al., 2007). However, experimental studies of the type that might establish a causal link between program implementation, student science learning, and other valued outcomes have yet to be conducted. Only a handful of studies have involved random assignment, and most of these have involved random assignment of students in a relatively small number of classrooms (see Furtak et al. 2009). With support from the U.S. Department of Education's Investing in Innovation Fund (i3), the current validation study of the LASER Model encompasses approximately 60,000 students, 1,900 teachers, and over 140 district administrators and principals.

Purpose

The purpose of this study was threefold: (1) to determine the impact of the Leadership and Assistance for Science Education Reform (LASER) model on science achievement for students in grades 1-8, (2) to examine LASER implementation fidelity across multiple settings, and (3) to determine the effectiveness of the LASER model in shifting students' attitudes toward science.

This study addressed the following key research questions:

1. Do students in schools that receive the LASER model over 3 years (i.e., Phase 1 schools) attain higher levels of science achievement than students in schools that do not receive the LASER model (i.e., Phase 2 schools) as measured by:
 - a. Partnership for the Assessment of Standards-based Science (PASS)-Basic (structured response/multiple-choice questions only)?
 - b. PASS-Extended (open-ended & performance tasks in addition to structured response questions)?
 - c. State assessments?
2. Do the student achievement results vary by subgroup?
3. What factors influence the implementation of the LASER model?
4. What is the impact of participation in the LASER model on student attitudes toward science?

Setting and Participants

The study sample includes 125 schools across three regions, including rural and urban schools in 16 districts. (Please insert Table 1 here.) The districts serve primarily Hispanic and White populations (44.4% and 25.8%, respectively), with more than two-thirds of students (70.0%) identified as "economically disadvantaged". The study sample is also comprised of 10.2% African American students, 2.5% American Indian/ Alaskan Native students, and 1.6 % Asian students. A subsample of approximately 9,000 students who were in fourth or seventh grade during the 2012-13 school year are being followed longitudinally over the three years of the study, which began in the 2011-12 school year, and comprise the data analytic sample reported on in this proposal.

Intervention Program

Developed by the Smithsonian Science Education Center (SSEC), the Leadership and Assistance for Science Education Reform (LASER) model is intended to improve the quality of classroom science instruction through a “systemic” approach that engages participants at every level, from classroom teachers up through the highest levels of district, regional, and state leadership. LASER employs the STC science curriculum (also developed by the SSEC), a set of kit-based instructional units that emphasize inquiry-based instruction, i.e., science instruction that engages students in *doing* science rather than just learning *about* science.

Through leadership development programs, participants learn to implement a new vision of effective science learning and teaching along with five critical areas of the system or infrastructure that need to be in place for improving teaching and student achievement: (a) research-based instructional materials using the Science & Technology Concepts (STC) science curriculum; (b) differentiated professional development programs that help teachers move from novice to competency; (c) aligned and cognitively-demanding assessments; and (d) cost-efficient and sustainable systems. The goal of the LASER model, a 5-year intervention system designed for students in first through eighth grade, is to provide multi-layered, systemic support to improve the quality of science education in participating districts. (Please insert Figure 1 here).

Research Design

This study utilized a mixed-methods approach with school-level randomized matched-pair design to examine student science achievement, including qualitative feedback gleaned from surveys and case studies. Implementation fidelity, as measured by random observations of science lessons, was also a key factor of this evaluation.

Participating schools in all three regions were matched on the following variables, then randomly assigned to treatment and control groups: Percent Proficient State Science Assessments, Percent Non-White, Percent Female, Percent Economically Disadvantaged, Percent of Students with a Disability, Percent of Students who are Limited English Proficiency, Total number of students, Total Number of Suspensions, Attendance Percentage. Treatment schools received immediate implementation of the LASER model, while the control group was assigned to delayed implementation, and will receive the LASER intervention after the research study has ended.

Instrumentation

Student Science Achievement. Two science assessments were used in this study. The primary achievement outcome measure is the PASS, selected by CREP and developed by WestEd, which is a reliable and valid assessment aligned to inquiry-based science. PASS consists of a combination of multiple-choice (PASS-Basic), constructed response (open-ended), and performance items (PASS-Extended). Finally, PASS measures student science achievement at two grade bands, 3-5 and 6-8, and is thus suitable for both the elementary and middle school cohorts in the study. As a secondary measure, we will use state achievement tests, which vary by state and have changed recently; therefore, descriptions of those tests will not be included here.

Implementation Fidelity. STC Unit Logs were developed by CREP to record STC implementation data from science teachers in grades 1-8. The STC Unit Log asks teachers to document the extent to which they were able to teach the unit as designed. The STC Unit Log

provides overall mean ratings from “Not Observed” to “Excellent” across 20 items on a four-point Likert scale asking questions such as, “Did you teach the lessons in the suggested sequence?”

Student Attitudes Toward Science. The PASS also includes 15 items that address students’ attitudes towards science, such as how much they like science, if science will be useful to them, and how much they discuss science with their family and friends.

Procedure and Analysis

The current study was conducted from August 2010 through May 2012. The participating districts were identified by the program developers and voluntarily agreed to participate. The districts also agreed to implement the LASER model as designed. Treatment schools immediately received the LASER model, and baseline data collection began prior to the implementation of the model. The control group was assigned to receive the LASER model in Summer 2014, after the research study has ended.

Exploratory analyses of outcomes on the 29 multiple-choice PASS items were conducted to determine differences between Phase 1 and Phase 2 students in third grade and sixth grade on Spring 2012 PASS-Basic (PASS-B) scaled scores (first post test). Only students who answered at least one question were included in the analyses for the respective grade, with each student’s scaled score on the Spring 2012 PASS-B used as the outcome measure. Hierarchical or “block entry” multiple regressions were conducted taking into account the following covariates: Special Education status (IEP), English Language Learner (ELL) status, Free and Reduced Price Lunch (FRL) status, and Fall 2011 (baseline) PASS scaled score. In addition to these regressions, a second set of ANCOVA analyses were conducted for all students within grade level, as well as for subgroups of these same students (by IEP status, ELL status, FRL status, and Gender) using the same covariates. Analyses of Spring 2013 data for both the PASS-Basic and PASS-Extended, as well as state achievement test, are currently underway and will be available for presenting at the Spring 2014 SREE conference.

For student attitudes towards science and the STC Unit Log implementation measure, descriptive statistics have been conducted thus far to examine stakeholder perceptions as well as levels of implementation fidelity. To be included in the survey analyses, a student had to have answered at least one question in Fall 2011 and one question in Spring 2012.

Results

Student Science Achievement. A total of 5,410 third grade students in Phase 1 ($n = 3,026$) and Phase 2 ($n = 2,384$) schools were included in the achievement analyses. The addition of the students’ Phase in the final block of the regression model was statistically significant, and favored Phase 1 ($Beta = .02$, $t = 1.97$, $p = .049$). However, the effect size ($g = 0.04$) from the ANCOVA demonstrated that the performance edge for Phase 1 was not substantively important (i.e. ≥ 0.25) according to What Works Clearinghouse standards (What Works Clearinghouse, 2011). All favoring Phase 1, other statistically significant ANCOVA outcomes were observed for the 276 IEP treatment students over their 220 controls ($F(1, 490) = 4.72$, $p < .05$, $g = 0.15$), the 1,124 treatment students not on Free/Reduced lunch over their 907 controls ($F(1, 2025) = 9.80$, $p < .01$, $g = 0.11$), and the 1,531 Male treatment students over their 1,209 counterparts in the control group ($F(1, 2734) = 4.49$, $p < .05$, $g = 0.06$). In all three cases; however, the effect sizes were not substantively important.

For the 2,796 sixth grade students in Phase 1 ($n = 1,376$) and Phase 2 ($n = 1,420$) schools included in the analyses, there were no statistically significant difference in achievement, taking into account all of the other variables in the previous blocks ($Beta = 0.01$, $t = 0.65$, $p = .514$), with an accompanying $g = 0.02$ effect size from the ANCOVA analysis. In addition, there were no statistically significant differences observed when subgroup ANCOVA adjusted means were analyzed.

Student Attitudes. In third grade, 2,650 Phase 1 and 1,835 Phase students were included. A vast majority of both Phase 1 and Phase 2 students (roughly 90% - 92%) in both Fall 2011 and Spring 2012 gave affirmative responses, stating “I like science” either “a lot” or “a little”. At both time points, while almost half of third grade students across the three regions recognized that science would be useful to them when they were older, a much lower percentage (roughly 17% - 24%) wanted to be a scientist when they grew up. Furthermore, 3rd grade students across the three regions at both time points were more likely to talk to family compared to friends about what they did in science class.

In sixth grade, 1,337 Phase 1 and 1,388 Phase 2 students were included. Overall, a vast majority of both Phase 1 and Phase 2 students (roughly 86% - 94%) in both Fall 2011 and Spring 2012 gave affirmative responses (“I like science” either “a lot” or “a little”). At both time points, while almost half of sixth grade students across three regions recognized that science would be useful to them when they were older, a much lower percentage (less than 10%) wanted to be a scientist when they grew up. Also at both time points, sixth grade students across the three regions were more likely to talk to family compared to friends about what they did in science class.

Fidelity of LASER Implementation. Results indicated that 551 STC Unit Logs were completed. Across all regions, over 95% of teachers reported teaching the units in the order intended. Over 85% of teachers answered “completely” or “to a large extent,” when asked if they taught all of the lessons/activities in the unit, indicating that most units were also taught in their entirety. Only 9.5% of teachers across all three regions reported teaching the unit completely as a teacher demonstration, as opposed to allowing the students to work with kits hands-on, as intended by the curriculum developers. At least 88% of teachers across all regions reported having all the materials needed to teach their units.

Conclusions and Educational Significance

Early findings from the current study indicated promising findings at third grade and possibly indication that implementing inquiry-based science early in students’ education may produce larger growth in science achievement, and may have differential impacts for specific subgroups, as evidenced by the positive finding for IEP students. The lack of findings for middle school will warrant further exploration if that trend in outcomes continues. The effects on student attitudes, however, are less clear, and appear to have less impact to date. It could be that if differences in achievement continue, differences in attitudes will follow. The efficacy of the LASER program has important implications for both research and practice when working with high-poverty schools and districts, who have limited resources and time available for science interventions. LASER’s initial success with early learners also demonstrates its potential for reducing the development of chronic, long-term deficiencies and academic problems.

Appendices
Not included in page count.

Appendix A. References

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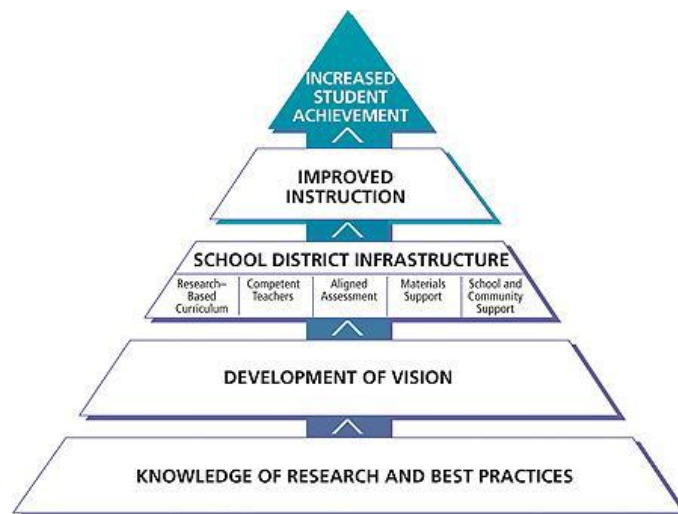
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Appendix B. Tables and Figures

Table 1. Current Research Study Sites by Condition

Region	Schools	Phase 1 (Treatment)	Phase 2 (Control)
Houston Independent School District	50	26	24
New Mexico (Eight districts)	33	19	14
North Carolina (Seven districts)	42	21	21
Total	125	66	59

Figure 1. Theory of Action for the LASER Model



The NSRC developed this theory of action to guide school districts in the process of establishing research-based science education programs that result in improved instruction and increased achievement for all students.

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